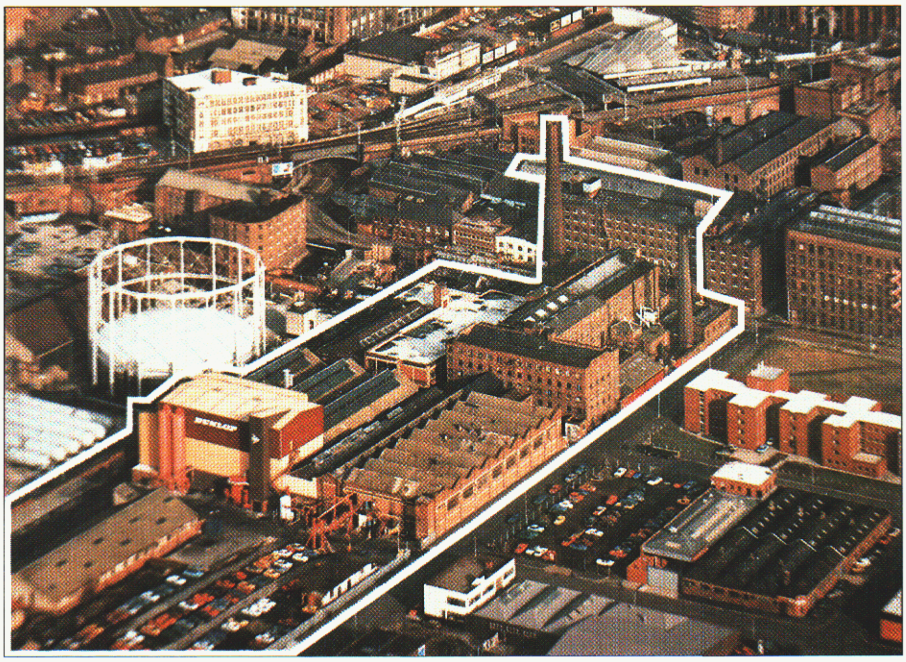
Case Study 272

Energy efficiency in refurbishment of industrial buildings

Dunlop Ltd, GRG Division
Cambridge Street,
Manchester

- Management developed and implemented company energy policy
- Energy survey showed scope for improvement
- Boiler fuel consumption cut by 23 million kWh/year (47%)
- 72% saving in space heating energy requirement
- Building energy related CO_2 emissions reduced by 2450 tonnes/year (60%)
- New BEMS proves its worth
- Steam distribution system improved
- Steam boiler replaced
- Fast-acting doors installed



Summary
Between 1986 and 1992, improvements to a steam generation and distribution system at the Dunlop Ltd GRG (General Rubber Goods) 53 000 m² site in Manchester were the main reason for a 47% reduction in boiler fuel consumption – down from approximately 49 million to 26 million kWh/year, saving approximately £230 000/year and the cost of six full-time boiler operators. These savings are contributing to investment in further energy efficiency measures.

This system supplies steam to a number of manufacturing processes at the factory, as well as being the primary source of space heating for the numerous buildings on site. Over the period in question (during which factory production remained virtually constant), the space heating share of boiler fuel consumption fell by over 72%, from 10.4 million to 2.8 million kWh/year.

The potential for energy saving, and possible ways to achieve it, were identified by an EEO (Energy Efficiency Office) grant-aided survey that was carried out in 1986.

The boiler fuel savings were achieved by a series of measures that included eliminating redundant parts of the system; installing condensate return; improving insulation of the steam pipes; using a new BEMS (building energy management system) to improve control of the system; and replacement of aged central, coal-fired steam boilers with a higher efficiency oil-fired unit.

As well as boiler fuel, the heating, lighting and processes consume a comparatively small amount of natural gas and electricity. A number of inefficient steam heater units have been replaced with gas radiant heaters, giving a small increase in gas consumption and reducing overall energy use. Lighting systems have been upgraded with higher efficiency luminaires, achieving improved lighting levels throughout the factory while lighting electrical consumption has remained virtually constant. Taking all fuels into account, the buildings-related energy use came down by over 58%, from 231 kWh/m² in 1986 to 95 kWh/m² in 1992. Figure 3 (back page) provides a summary of boiler fuel, gas and electricity consumption for each year from 1986 to 1992.

Background
Production of rubber goods on Dunlop GRG Division's site, close to the centre of Manchester, dates back to 1824 when Charles Macintosh opened a small factory to make rubber-proofed textiles. This venture led to production of the highly successful Macintosh raincoat, and to satisfy demand it

“This site illustrates the potential for a significant reduction in energy costs on a location with ageing buildings”

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

was necessary to expand the factory across several streets, with a succession of new buildings erected over an extended period.

The site now comprises a variety of mainly 19th Century office and factory buildings, traditionally built with solid stone or brick walls and pitched slate roofs, and linked under and over the streets in places by tunnels and bridges. The only major additions this Century have been a small, single-storey building that was erected in the 1940s, and the Compound Mixing Department (a lofty, steel-framed structure designed to house process equipment) that was commissioned in 1982.

Dunlop acquired the factory in 1925, and continued with the manufacture of raincoats until the outbreak of World War II. Products that are currently made on the site range from flexible fuel containers to vehicle component mouldings and solid industrial tyres. The total heated area is 49 192 m^2, including offices, and about 280 people are employed throughout the site.

Management Policy

In common with many long-established manufacturing organisations, Dunlop's GRG Division paid little attention to energy costs before the mid-1980s, and had no specific energy management policy.

By 1986, however, there was increasing concern about the fast-rising costs of energy, and the company decided to have an EEO grant-aided energy survey carried out.

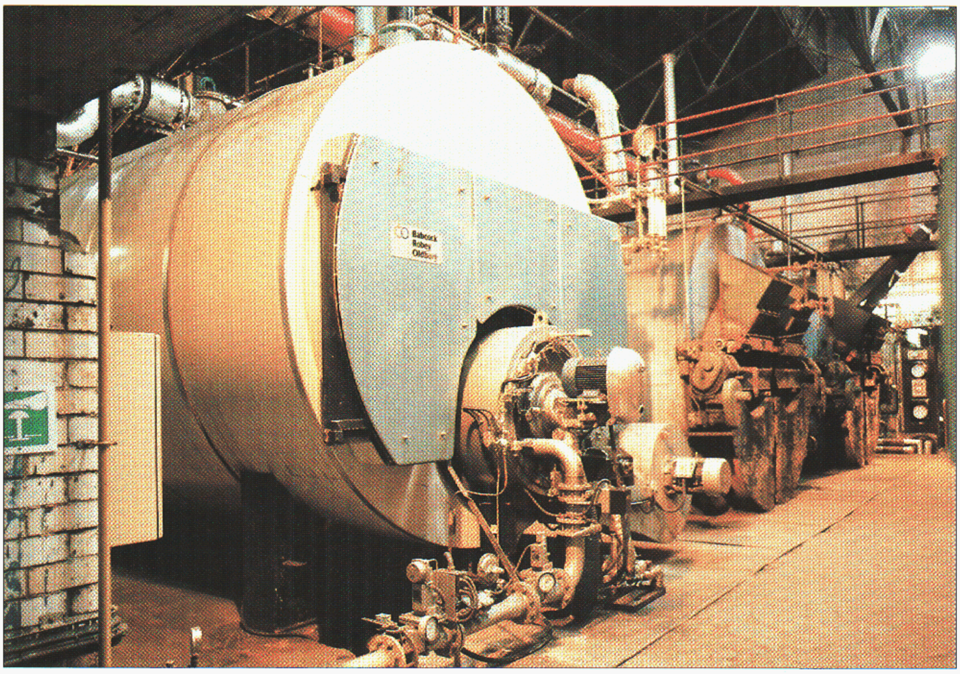
This survey identified areas of major energy wastage within the factory's steam distribution system, aggravated by lack of controls. The main recommendation was for rationalisation of the distribution system, followed by the introduction of a BEMS, and culminating with replacement of the boiler plant.

The company accepted this recommendation, and decided that its effective implementation would require an energy manager. Initially, this person's main duties were to develop the use of the BEMS, and to push through other aspects of the energy efficiency programme.

Since then, the energy manager's role has been diversified, but regular energy monitoring has continued and is recognised as essential management practice.

Sequence of events

1986	EEO grant-aided energy survey carried out.
1987-88	Steam distribution pipework rationalised, redundant sections eliminated. Motorised isolating valves installed. Some steam warm air heaters replaced by gas-fired radiant units. Additional thermal insulation provided to steam distribution system. Condensate return system extended. Fast-acting door installed.
1988	Energy Manager post established, and operation of BEMS developed.
1990	Coal-fired boilers replaced by a single oil-fired unit.



Replacement oil-fired boiler (old boilers behind)

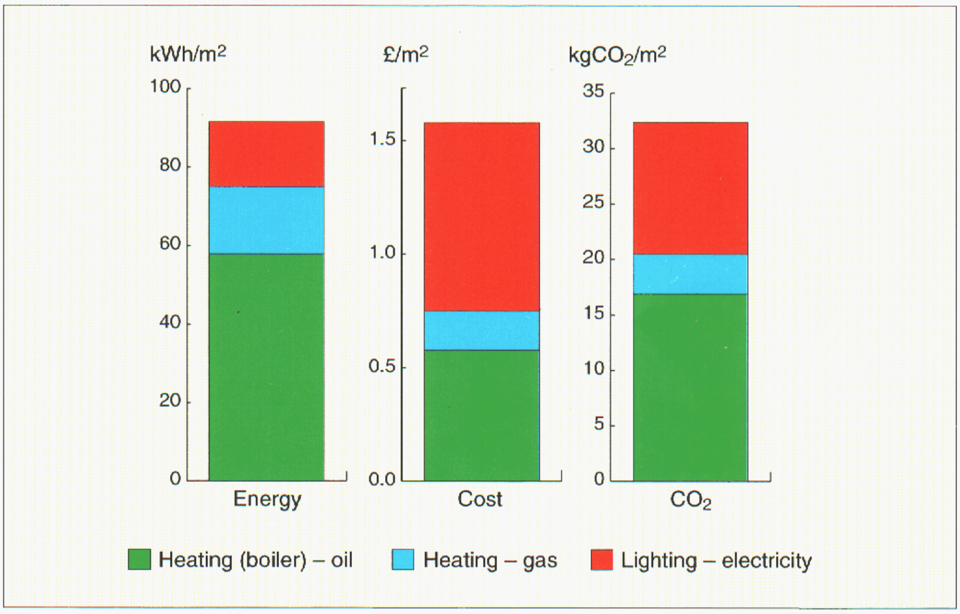


Figure 1 Energy, cost and CO_2 by end-use 1992

Building services

Process and space heating throughout the factory are served by a central steam boiler plant with distribution via an extensive network of large pipes. At the time of the energy survey the boiler plant was coal-fired. Isolation, and insulation standards of the distribution network were poor, with consequent high standing losses in both winter and summer. In addition condensate was run to drain, resulting in further loss of energy.

Most of the work on the steam distribution and condensate return pipework was completed during the 1987/88 summer shutdowns, with no adverse effect on production. Provision was made during this work for motorised valves to be controlled via the BEMS.

The condensate collecting system was extended to return uncontaminated steam condensate to the boiler. (A small proportion of the condensate is contaminated by contact with rubber). Recovering the condensate resulted not only in energy cost savings, but also operating cost savings due to reduced boiler feed water treatment.

Replacement of the aged coal-fired boilers with a new single oil-fired unit, during the 1990 summer shutdown resulted in further savings due to the higher combustion efficiency, and elimination of coal consumption for boiler idling (banking) overnight and at weekends. The automatic operation of the new boiler has also significantly reduced associated staff costs; six employees were required full-time to operate the old boilers.

Modifications to space heaters

Improvements in space heating arrangements in several of the buildings led to useful additional savings in boiler fuel. For example, some ineffective steam-heated air handling units were replaced by gas-fired radiant plaque and radiant tube heaters. In one of the buildings, where warmth provided by process heat emissions are normally sufficient, the new gas heaters are turned on manually by the operators, and turned off automatically after two hours by timer switches on the controls.

In the Security Lodge, steam coil heaters were replaced by higher efficiency gas-fired, balanced-flue convector heaters.

To maximise efficiency and effectiveness, most space heating systems are now controlled via the BEMS.

Fast-acting doors

Comfort levels and heating costs in a building that is frequently accessed by fork lift trucks were greatly improved in 1988 by fitting a fast-acting door that can be easily activated by the truck operators. A welcome additional benefit is that product quality is no longer impaired, as it was before, by the chilling effect of cold draughts.

Encouraged by this success, and strongly influenced by requests from operators, a similar door was installed in the Compound Mixing building during early 1993.

Lighting

The majority of lighting systems have been upgraded and modernised in recent years, with most of the tungsten luminaires replaced by higher efficiency fittings. These changes have allowed major improvements in illuminance levels throughout the factory, with no significant change in overall electrical consumption. The company says that improved lighting has contributed to improved product quality, and has been welcomed by all personnel.

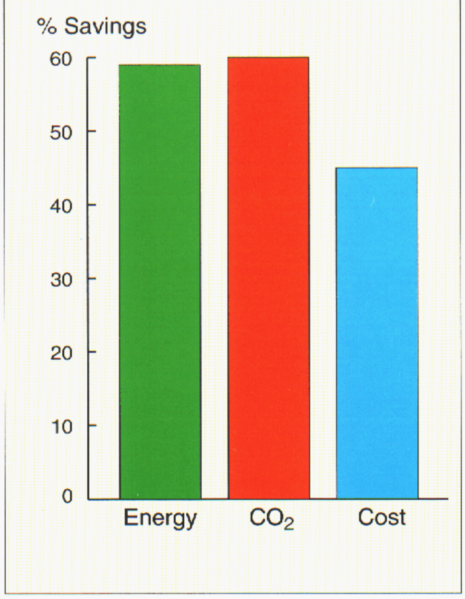


Figure 2 Building-related energy savings – 1986 to 1992

Building Energy Management System

A central computerised BEMS was installed during 1988, and became fully operational from 1990.

The system communicates at present with 14 outstations, each of which has up to five outputs. Currently 33 outputs are used for space heating control, and 29 for process or common services such as boilers. One output is used for lighting in a production area; further use of the BEMS to control lighting is planned.

Most of the space heating areas are time controlled only, since excess temperature levels are not normally encountered, but some areas include temperature control matched to comfort limits.

User reaction and appraisal

The working environment has been significantly improved by the BEMS, particularly in avoiding overheating adjacent to process equipment that is generating heat. There has been a general acceptance of changes to heating systems.

A fast-acting external door has eliminated many of the draughts associated with high traffic movement and has been particularly welcomed by fork-lift truck operators.

Provision of improved lighting levels has been fully welcomed, particularly since the main rubber products are black and have poor reflective properties.

Main conclusions

This site illustrates a significant reduction in energy costs on a site with ageing buildings. The improved performance has been achieved in spite of the generally poor insulation properties of the buildings, mainly through flexible and appropriate control using the BEMS. This has minimised unnecessary heat loss and eliminated overheating conditions which were occurring in certain areas.

Good energy management is now incorporated in management practice, with continued monitoring of energy performance. Further improvements such as heat recovery, and BEMS lighting control are planned for future projects.

Environmental impact

Burning fuel to generate energy produces gases from extraction, processing, delivery and combustion of the fuel, at power stations or on site. Carbon dioxide (CO_2) especially is a major contributor to the greenhouse effect and the threat of global warming. The government is committed to reducing CO_2 emissions. Efficient use of energy not only reduces costs, but also demonstrates a commitment to improving the environment.

CO_2 emissions per unit of energy delivered to a site depend on the fuel source, electricity generating mix, and other assumptions. Current values are: Gas 0.21, Oil 0.29, Coal 0.32, Electricity 0.72 kg CO_2/kWh delivered fuel. The value for on-site combined heat and power (CHP) generation can be much lower.

Energy performance

Buildings-related energy savings of 58% have been achieved at the Dunlop GRG factory, between 1986 and 1992. This has resulted in a 60% reduction in carbon dioxide emissions and a 45% reduction in fuel cost (see figure 2 and 'Notes on energy costs' below).

Energy consumption values for Dunlop are given below for comparison with the values from Energy Consumption Guide 18[1] taking into account the effect of building height, occupancy and other influences.

Dunlop annual energy consumption values (kWh/m^2):

	1986	1992
Fossil fuel	215	79
Electricity	16	16

(The space heating component in these values has been corrected for weather using degree-days, a correction of -3.5% in 1986 and +6.3% in 1992).

Indicative annual values from Energy Consumption Guide 18[1] for a 'General Manufacturing' type building, typically 8 m in height with 2-shift operation (kWh/m^2):

	'Typical'	'Improved'
Fossil (heating & hot water) kWh/m^2	325	225
Electricity kWh/m^2	85	65

Dunlop GRG has building heights which vary from 3 m to 9 m, averaging about 3.5 m. It has single shift occupancy, and significant heat gains from processes in some areas.All these will reduce the heating energy consumption (90% of the fossil fuel). After allowing for these factors, Dunlop's fossil fuel consumption compares well. The single shift occupancy will also reduce lighting consumption (90% of the electricity used), as will the low density of occupation of the buildings. Taking this into account, electricity consumption compares well. (Energy Consumption Guide 18[1] and 'Introduction to Energy Efficiency in Factories and Warehouses'[2] give further information).

Figure 1 (page 2) gives a breakdown by fuel, and shows that while electricity is a small proportion in energy terms, it is significant in terms of cost and CO_2 emissions.

Notes on energy costs

Fuel costs vary with factory size, type, region, contract and load profile. 'Unit prices' tend to be lower for larger sites because of a better negotiating position. For this reason, and to protect the confidentiality of individual sites, the following typical unit prices have been used in all studies in this Case Study series.

Typical unit price (p/kWh delivered)

	Fossil	Electricity
Large site	1.0	5.0
Small site	1.3	8.0

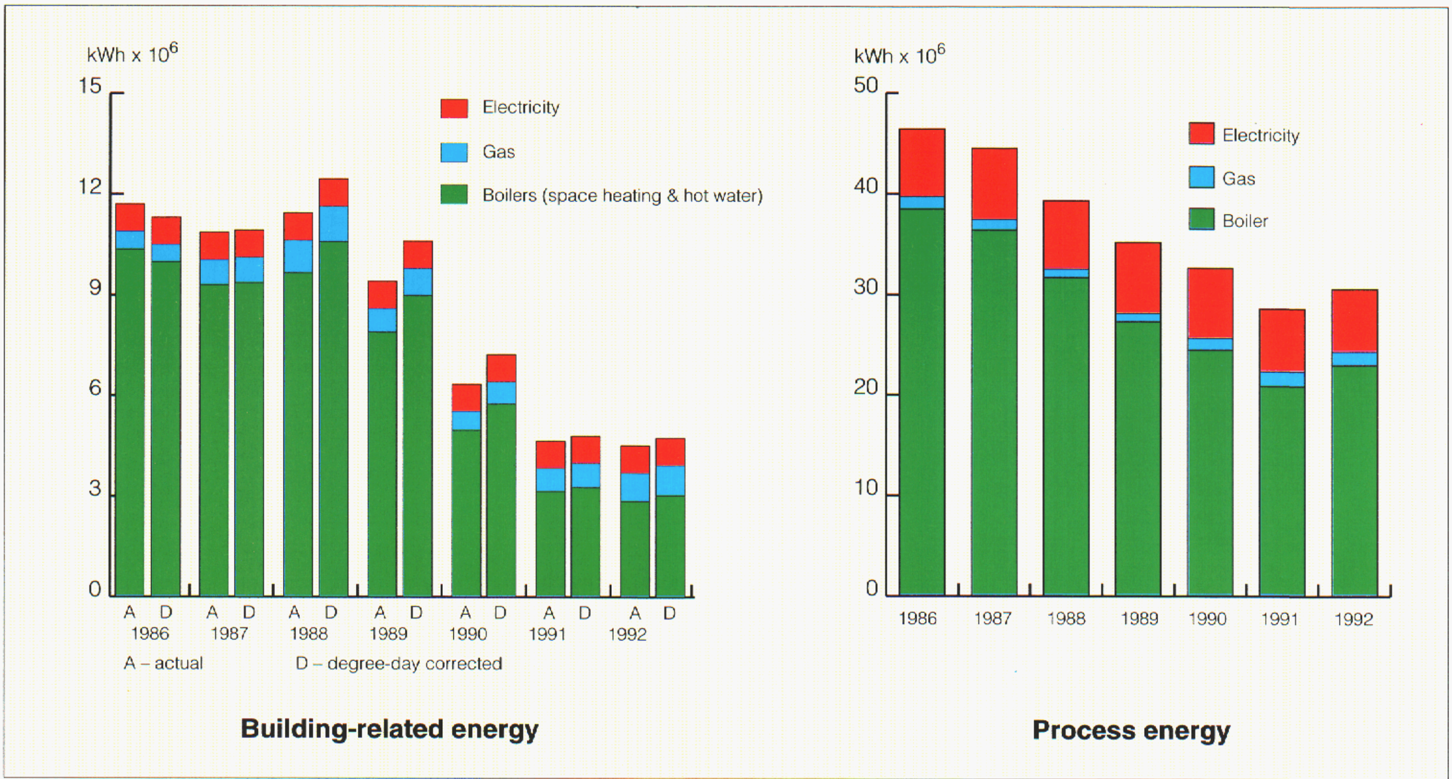


Figure 3 Annual energy consumption (referred to on front cover)

	Investment costs (1992 equivalent) (£)	Building-related Annual energy saving (million kWh)	Building-related Annual cost saving (£)	Process-related Annual energy saving (million kWh)	Process-related Annual cost saving (£)
1987/89 Distribution pipework rationalised Motorised zone valves installed Pipework installation improved Condensate return installed Radiant plaque heaters installed Fast-acting door installed BEMS installed	96 600	5.37	53 700	14.078	140 780
1990 Oil fired boiler installed	223 400(1)	1.835	18 350(2)	1.341	13 410(2)

(1) The investment was also necessary to replace aged boilers. (2) In addition, the cost of six full-time boiler operators was saved.

Summary of measures and savings

References

1. Energy Consumption Guide 18. Energy efficiency in industrial buildings and sites, London, EEO, 1993.
2. Introduction to energy efficiency in factories and warehouses, London, EEO, 1994.

Contact BRECSU for these and other Case Studies and Guides on energy efficiency in industrial buildings.

Acknowledgements

The co-operation of the owners, managers and occupants of the case study site is gratefully acknowledged.

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